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METHOD FOR JOINING TOGETHER PARTS CONSISTING AT LEAST PARTLY OF WOOD OR WOOD-LIKE MATERIALS

Marcel Aeschlimann et al.

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METHOD FOR JOINING TOGETHER PARTS CONSISTING AT LEAST PARTLY OF WOOD OR WOOD-LIKE MATERIALS

[Verfahren zum zusammenfügen von teilen, die mindestens zum teil aus holz oder aus holzähnlichen materialien bestehen]

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Applicant (for all contracting nations except US):	Createc Patent Holding S.A.
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The invention pertains to the wood working industry, in particular, to a method according to the preamble of the first independent claim for joining together parts that consist at least partly of wood or wood-like materials. /1*

According to the state of the art, parts of wood or wood-like materials (derived timber products), for example, plywood or particle boards, are either joined together with mechanical connecting means, for example, screws or nails, or glued to one another, wherein an adhesive is usually applied onto the two surfaces to be joined together and both surfaces are subsequently pressed together during a drying and hardening time that depends on the type of adhesive. Parts of wood or wood-like materials are also connected to plastic parts with these or similar methods.

If the objects produced by joining together the above-mentioned parts should be varnished, i.e., treated with a colorless varnish or a colored paint, the following problems arise depending on /2
the joining technique and the varnish used: damage to the previously applied paint or varnish layer can hardly be prevented when using screws or nails; a varnish layer on surfaces that are joined together with glue can negatively influence the adhesive properties of the glue; glue that is pressed out of joints can negatively influence the adhesive properties of subsequently applied paints and varnishes or discolor varnishes or paints applied before the gluing process. Even on parts that are joined together by means of glue and not varnished, slight quantities of glue being pressed out of the joints are unsightly and difficult to prevent. If the parts are varnished after they are joined together, the joints remain unvarnished and unprotected such that their durability is reduced.

The invention is based on the objective of disclosing a method for joining together parts that consist at least partly of wood or wood-like materials, wherein said method represents an improvement referred to the above-described disadvantages. It should be possible to easily carry out the method according to the invention whether the parts to be joined together are varnished with a protective and/or colored varnish before or after they are joined together.

This objective is attained with the method defined in the claims.

The invention essentially proposes to place at least one layer that consists at least partly of a thermoplastic plastic material between two parts to be connected to one another, of which at least /3
one consists of wood or a wood-like material, wherein both parts are then connected to one another by means of a mechanical excitation. The mechanical excitation preferably is realized with ultrasonic waves (ultrasonic welding), wherein at least one of the parts to be connected or its connecting surface is excited to vibrate with an ultrasonic frequency. For this purpose, at least one of the parts to be joined together is held under a welding pressure between a surface that can be excited with ultrasound (working surface of a sonotrode) and an anvil in the region of the connection to be produced and subjected to ultrasonic waves, wherein the ultrasonic waves may

* [Numbers in the right margin indicate pagination of the foreign text.]

propagate perpendicular, parallel or oblique referred to the surfaces to be connected. The parts are connected to one another by means of the thermoplastic layer after a short welding time and preferably a brief holding time.

Instead of an ultrasonic welding process, it would also be conceivable to utilize frictional welding or orbital welding, wherein the surfaces to be joined together are essentially moved parallel to one another (linear or cyclic).

The at least one thermoplastic layer to be placed between the parts to be connected may consist of a protective and/or colored varnish that is applied onto the wood part or the wood parts and consists of a thermoplastic material or at least contains thermoplastic components, wherein the conventional function of this paint consists of protecting the wood surface from, for example, atmospheric influences and/or coloring this surface with a certain color. In this case, the first step of the method according to the invention consists of applying a liquid varnish onto the wood surface, for example, by means of brushing, spraying, immersing, rolling or pouring, wherein this varnish subsequently dries or hardens on the surface. The application and drying of the varnish can /4
be repeated, for example, such that a base coat is initially applied and the varnish layer is subsequently applied thereon. The varnishing may be limited to the surface regions to be joined together, but preferably extends over other regions that from part of the surface of the finished object composed of the connected parts. It is also possible to varnish the parts to be joined together in their entirety. In a second step, the surfaces to be joined together, of which only one or both carry a (preferably dried or hardened) varnish layer, are brought in contact with one another and subjected to an ultrasonic welding process. This variation of the method makes it possible to connect, for example, two wood parts (of which at least one is varnished) or a varnished wood part to an unvarnished plastic part consisting of a thermosetting material.

It is also possible to carry out the welding process before the last varnish layer applied has completely dried or hardened. It has been determined that the welding process even accelerates the drying or hardening of the varnish in such instances.

The at least one thermoplastic layer to be placed between the parts to be connected may also consist of a thermoplastic film. This variation makes it possible to connect, for example, two (varnished or unvarnished) wood parts to one another or to connect one (varnished or unvarnished) wood part to a part consisting of a thermosetting material.

In another variation of the method according to the invention, a part consisting of a thermoplastic material or of a material that at least contains thermoplastic components is /5
connected to a (varnished or unvarnished) wood part, wherein the surface layer of the thermoplastic part which faces the wood part serves as the thermoplastic layer.

The method according to the invention is described in greater detail below with reference to the figures. The figures show:

Figures 1-3, three exemplary variations of the method according to the invention;

Figure 4, the tensile strength of different connections produced with the method according to the invention;

Figure 5, a diagram illustrating the influence of welding parameters on the tensile strength of a connection produced with the method according to the invention;

Figures 6-8, different applications of the variations shown and Figures 1 and 2;

Figures 9-11, different applications of the variation shown in Figure 3, and

Figure 12, a surface to be connected with the method according to the invention which is equipped with energy directing elements.

Figure 1 schematically shows one exemplary variation of the method according to the invention, in which two wood parts A and B that are both varnished (varnish layer L) are connected to one another. A conventional ultrasonic welding system is utilized for the welding process. This /6
welding system contains a surface 1 that can be excited with ultrasound (working surface of a sonotrode 4) and a stable anvil surface 2. In this case, the parts A and B to be connected which, for example, are covered by the varnish layer L on all sides (as shown) are held between the sonotrode working surface 1 and the anvil surface 2 under a welding pressure P. Lateral holding means (indicated by arrows S in the figure) are usually required in order to prevent a lateral displacement of the parts A and B to be joined together.

In order to generate and transmit the ultrasonic energy, the ultrasonic welding system comprises the following parts (which are not shown in Figure 1): a generator for generating electromagnetic waves with a frequency that usually lies between approximately 18 kHz and 140 kHz (for example, 20 or 40 kHz), a converter that converts the electromagnetic waves into mechanical waves and usually consists of several interconnected piezoelectric elements, and a resonator (that frequently consists of two parts, namely a booster and the sonotrode 4). This resonator transmits the generated mechanical waves onto one of the parts (A) to be welded together via the above-mentioned excitable surface 1 (working surface of the sonotrode 4) via the mechanical coupling, wherein the resonator may, if so required, also subject the mechanical waves to an amplitude transformation.

The mechanical waves generated by the converter are transmitted with the least possible losses by carefully harmonizing the materials and shapes of the converter, the booster and the sonotrode such that these parts resonate and standing waves (with stationary nodal points) are generated.

The requirements to be fulfilled by the parts to be joined together and the varnish for the /7
ultrasonic welding of varnished wood parts (variation according to Figure 1) are described below:

-in its dried or hardened state, the varnish needs to contain at least one thermoplastic component; this is the case with many synthetic (clear or colored) varnishes as well as water-soluble and solvent-soluble varnishes available on the market;

-the surfaces of the parts that are joined together need to be parallel within relatively strict tolerances, wherein wood surfaces with a normal roughness for surfaces to be varnished (for example, planed or shaped) can be adequately processed. In addition, it must be possible to laterally guide and press against one another the surfaces to be connected for a very short welding time (on the order of one second) and, if so required, a short holding time (on the order of a few seconds).

The advantages achieved with the variation of the method according to Figure 1 in comparison with a glued connection are described below:

-in the method according to the invention, the wood surfaces to be connected may be arbitrarily aligned relative to the wood grain, i.e., it is not only possible to produce, in particular, cross-cut to cross-cut, cross-cut to straight-cut or straight-cut to straight-cut connections, but also connections between connecting surfaces that are obliquely aligned relative to the grain;

-two functions can be realized by applying only a single material (varnish) onto the surfaces of the wood parts: the varnish fulfills a protective and/or coloring function on exposed surfaces of the finished object and the function of a connecting means (comparable to the function of an /8 adhesive) in the form of a weldable coating on the joined the surfaces of the parts;

-the manufacture of an object that consists of such interconnected parts and is varnished can be accelerated because the separate application of an adhesive and a drying or hardening time for the adhesive are eliminated. The required welding times (including the holding time) are very short (a few seconds);

-the manufacture of multi-colored objects can be simplified by coloring the parts before they are joined together;

-instead of varnishing entire objects, it is also possible to only varnish individual parts. This may make it possible to reduce the size of the required apparatuses, in particular, for larger objects and in immersion or tunnel varnishing systems;

-in objects with several joints, it is possible to successively weld these joints without causing a noteworthy increase in the time required for the joining process such that the required clamping devices can be simplified and reduced in size;

-the length of the storage time between the varnishing process and the welding process is arbitrary.

Tests on parts consisting of beech and fir woods (see also Figure 4) which were carried out with acrylic varnishes demonstrated that varnishes applied in a conventional thickness on the order of 0.1 mm made it possible to produce ultrasonically welded connections with tensile strength on

the order of approximately 10 N/mm^2. According to the pertinent DIN standards, this corresponds /9
to the required strength of connections between wood parts which are produced with conventional adhesives and exceeds the tensile strength of, for example, the wood of European coniferous trees.

It is also possible to connect varnished wood parts to unvarnished wood parts or varnished wood parts to thermosetting plastic parts in the same fashion as illustrated in Figure 1. Advantageous applications of the variation according to Figure 1 are, for example, the joining of varnished parts into window frames, picture frames or other frames, or the application of parquet flooring strips onto carrier plates of a wood-like material. Another application is the attachment of end strips consisting of thermosetting material or varnished or unvarnished wood slats onto the end faces of varnished particle boards. Details regarding other applications of the variation according to Figure 1 are illustrated in Figures 6-8.

Figure 2 shows a second exemplary variation of the method according to the invention in the form of a schematic representation analogous to Figure 1. In this case, two wood parts C and D are connected to one another, wherein a thermoplastic layer, for example, in the form of a thermoplastic film 5 is positioned between the two parts. Suitable thermoplastic films are, for example, commercially available films of copolymers of polyamide or polymethylene methacrylate (PMMA) with a thickness of, for example, 30-200 µm. It would also be conceivable for the thermoplastic layer 5 to be arranged between the surfaces to be connected to not consist of a film, but rather a powder that, for example, is held on one of the surfaces to be joined together by a thin, still moist varnish layer.

The welding step for the variation according to Figure 2 is carried out in the same fashion /10
as described above with reference to Figure 1; consequently, the parts of the welding device shown in Figure 2 are identified by the same reference symbols.

The variation shown in Figure 2, in which a thermoplastic layer in the form of a film or a powder layer is placed between the surfaces to be connected, makes it possible to connect varnished wood parts to one another, varnished to unvarnished wood parts or varnished or unvarnished wood parts to thermosetting material parts.

Examples for the application of the variation according to Figure 2 are window frames and other frames. The examples for application described with reference to Figures 6-8 may be carried out with the variation according to Figure 1, as well as the variation according to Figure 2.

Figure 3 shows a third exemplary variation of the method according to the invention in the form of a schematic representation analogous to Figure 1. In this case, a wood part E and a thermoplastic part F are connected to one another, wherein the surface layer of the thermoplastic part in the region of the connection serves as the thermoplastic layer.

The variation according to Figure 3 is suitable for connecting varnished or unvarnished
wood parts to parts that, for example, consist of polymethylene methacrylate, (PMMA), /11

acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), polyethylene (PE) or styrene-acrylonitrile (SAN).

Examples for the application of the variation according to Figure 3 are, for example, the attachment of thermoplastic strips onto the end faces of particle boards or the connection of varnished or unvarnished wood parts by means of dowels of a thermoplastic material as described in greater detail below with reference to Figures 9-11.

Figures 4 and 5 show the results of shear tension tests with parts that were varnished before there were joined together with the method according to the invention, wherein said tests were carried out in accordance with the test regulations stipulated in DIN EN 204 (the samples were manufactured in accordance with DIN 205). The varnish consisted of a transparent varnish by the firm Intex which was applied in two layers, namely in the form of a primer (type tlmf, acrylic-alkyd combination) and a top coat (type DSL, acrylic) with a total layer thicknesses of approximately 90 µm (dry). In addition, a white varnish by the same firm was utilized which was applied in three layers, namely in the form of a primer (type ISO, acrylic), an acrylic undercoat (type AVO) and a window top coat (type FSL, acrylic) with a total layer thickness of approximately 150 µm.

An ultrasonic welding system by the firm Branson (type 921) was used for carrying out the tests. The surfaces to be welded together consisted of plane surfaces that were aligned parallel to the sonotrode working surface and respectively had a surface area of approximately 400 mm^2. The welding parameters used were: frequency 20 kHz; maximum power 2000 W; amplitude (on the working surface of the sonotrode) approximately 60 µm; welding times between 0.2 and 1 second; holding time approximately 5 seconds and welding pressure (force for pressing together the parts /12
per unit surface of the surfaces to be connected) up to 300 kPa.

Figure 4 shows the tensile strength s in N/mm^2 (according to DIN EN 204) as an average value and 95% confidence interval for the following examples:

Sample	Wood	Surface	Varnish	Type of application	Welding time [s]
a	Beech	planed	Transparent	Brush	0.6
b	Beech	planed	Transparent	Brush	0.9
c	Beech	planed	Transparent	Blade	0.9
d	Fir	planed	Transparent	Blade	0.6
e	Beech	planed	Transparent*	Brush	0.6
f	Fir	planed	Transparent*	Brush	0.6
g	Beech	shaped	Transparent	Brush	0.6
h	Fir	shaped	Transparent	Brush	0.6

*Without primer

The parameters of an ultrasonic welding process are, in particular, the frequency of the ultrasonic waves generated, the oscillation amplitude of the working surface of the sonotrode and the surface to be welded of the part that is excited by the sonotrode, the power consumption of the system, the welding pressure P and the welding time.

The frequency and the maximum ultrasonic power are usually defined by the ultrasonic welding system. The amplitude of the oscillating working surface of the sonotrode depends on the amplitude of the converter and the choice of booster and sonotrode. The welding pressure, the amplitude and the power consumption are linked to one another within the system in such a way that the welding pressure is limited for a certain amplitude and a certain maximum power (the smaller the amplitude, the higher the attainable welding pressure), that the power consumption /13 increases at a constant welding pressure and a higher amplitude, and that the power consumption increases at a constant amplitude and a higher welding pressure.

Since the method according to the invention is usually carried out with so-called remote welding processes (welding surfaces that are spaced apart from the working surface of the sonotrode by more than approximately 1 cm), it is proposed to carry out the welding process with relatively high amplitudes.

The welding energy required for certain welding process is, among other things, defined by the type of varnish to be welded and the geometry of the parts to be welded together (energy losses in the part material). If the welding power is predominantly defined by the system, the welding energy is controlled by choosing the welding time accordingly.

Theoretically, an optimally energy-efficient welding process would be expected if the first part to be welded (A in Figure 1) were mechanically coupled with the sonotrode, would resonate with the sonotrode and were realized in such a way (arrangement of nodal points in this part) that its surface to be welded oscillates with a suitable amplitude for the welding process. In addition, the two surfaces to be welded together should be mechanically coupled to the least possible degree such that the waves only propagate insignificantly into the second part (B in Figure 1) and into the anvil. The two parts to be connected are no longer mechanically coupled as soon as the thermoplastic layer (e.g., varnish) arranged in between becomes soft.

Ultrasonic welding tests carried out with an arrangement according to Figure 1 /14
demonstrated that--despite the pressure ratios on the contact surfaces between the sonotrode and the varnished wood and between the anvil and the varnished wood being identical to those on the surfaces to be connected--adequate welding connections were produced without causing changes to the varnished regions on the contact surfaces with the sonotrode and with the anvil, i.e., the varnished surfaces did not adhere to the sonotrode and to the anvil after the welding process. In other words, the coupling between the sonotrode and the first part to be connected is sufficiently high while the coupling between the surfaces to be connected is sufficiently low. This applies, in particular, to the utilization of very smooth sonotrode and anvil surfaces. If these surfaces are rough or uneven, corresponding impressions may be created in the varnish layers contacting these surfaces during the welding process.

The welding parameters need to be determined experimentally for each specific application.

Figure 5 shows an example of a welding parameter optimization, namely of the tensile stress s [N/mm^2] of produced connections as a function of the parameters welding time t [s] and the welding pressure P [kPa]. The connections were produced between planed beech parts that were coated with the above-mentioned transparent varnish. The figure indicates that the highest tensile stresses are achieved at low welding pressures and long welding times.

Figures 6-8 show applications of the variation shown in Figure 1 or Figure 2, in which the surfaces to be welded together do not extend parallel to the sonotrode working surface 1 and the anvil surface 2 as in Figures 1 and 2. The varnish layers or thermoplastic films between the parts to be connected are not shown in these figures. As described above with reference to Figure 1, the /15
varnish layers at least extend within the regions of the surfaces of the parts A and B which need to be connected by means of welding. Identical parts are identified by the same reference symbols as in Figure 1.

Figure 6 shows that a welding connection 6 which extends obliquely referred to the sonotrode working surface 1 can also be produced with the method according to the invention, wherein the sonotrode working surface 1 preferably has the approximate size of the projection of

the welding connection as shown in the figure. Lateral holding means (arrows S) are particularly important for applications of this type.

Figure 7 shows an application, in which the function of lateral holding means is at least partly fulfilled by the shape of the welding connection 6. This connection consists of a welding connection to be produced between variably aligned welding surfaces. Connections of this type are utilized for numerous applications in wood engineering. A welding connection of this type can also be produced with the method according to the invention, wherein the sonotrode working surface 1 advantageously has the approximate size of the projection of the welding connection as shown in the figure.

Figure 8 shows a welding connection 6 to be produced which extends perpendicular to the sonotrode working surface 1 and the anvil surface 2. A welding connection of this type can also be produced with the method according to the invention. In this case, the lateral holding means (arrows S) fulfill part of the function of the welding pressure P. For this application, the sonotrode /16
working surface 1 is advantageously narrow and only excites one (A) of the parts to be connected as is also the case in the other described applications.

It is also possible to utilize anvil surfaces that do not extend parallel to the sonotrode working surface and/or uneven sonotrode working surfaces or anvil surfaces.

Figures 9-11 show an exemplary application of the variation according to Figure 3, namely the connection between varnished or unvarnished wood parts with the aid of plastic dowels. These dowels consist of a plastic material with at least one thermoplastic component. The dowels have a conical shape and their cross section is at least sectionally larger than the cross section of the bore, into which they are inserted. A dowel is positioned in a bore and pressed into the bore under pressure and the influence of ultrasonic waves. In this case, the shape of the dowel is simultaneously adapted to the shape of the bore, and the dowel surface is connected to the wood surface inside the bore analogous to the variation according to Figure 3.

Figure 9 shows an exemplary application of the dowel principle. Figures 10 and 11 show the designs of dowels and corresponding bores.

Figure 9 shows how two (varnished or unvarnished) wood parts G and H that respectively comprise a conical blind bore 7 can be connected by means of a plastic dowel 8 in accordance with the inventive method. The cross section of the dowel 8 is at least regionally larger than the cross /17
section of the bores 7 such that the dowels cannot be completely inserted into the bores. The dowel is pressed into the bore until both wood parts lie on top of one another under the influence of a welding pressure P and ultrasonic waves. If the wood parts are varnished, the varnish layers are also connected to one another at the contact points such that the connection between the two parts is additionally reinforced (as shown in Figure 6).

Naturally, it is not only possible to connect wood parts to wood parts, but also plastic parts or parts coated with plastic to wood parts with the variation shown in Figure 9. In this case, the required dowels are, for example, integrally formed onto the parts to be connected to the wood parts. One application of such a method is, for example, the attachment of fittings to wood parts.

Figures 10 and 11 show exemplary dowels 8.1 and 8.2, as well as corresponding blind bores 7.1 and 7.2. In Figure 10, the dowel 8.1 and the bore 7.1 contain steps 9, at which the respective diameters of the dowel and the bore are tapered toward the end of the dowel or the bore, respectively. In Figure 10 [sic; 11], the bore 7.2 has a continuously conical shape, wherein only the dowel 8.2 is provided with steps 9.

Exemplary dimensions for the dowels and the bores shown in Figures 9-11 are: bore: depth 24 mm, maximum diameter 8 mm, minimum diameter 5.5 mm, five steps with a reduction in diameter of 0.5 mm; dowel: maximum diameter 8 mm, minimum diameter 6 mm, four steps with a respective reduction in diameter of 0.5 mm, wherein the height of the steps approximately corresponds to the height of the steps in the bore.

The dowel and the bore may also contain more or less steps, wherein the bore contains, for /18
example, one step and the dowel does not contain any steps. In this case, the dowel diameter corresponds to the largest diameter of the bore.

It was determined that, when producing a connection as described in Figures 9-11, the thermoplastic material of the dowel penetrates into the wood by up to 50 mm. This causes locally very strong connections to be produced which exceed the stability of the wood. It was also determined that the dowel material penetrates into the wood, in particular, in the region of the dowel tip and, in particular, parallel to the wood fibers. For example, if a dowel is welded into a blind bore that is produced perpendicular to the lateral surface of the wood part (perpendicular to the fiber direction), the dowel material penetrates into the wood, in particular, in the region of the blind bore end and, in particular, transverse to the blind bore such that the dowel is truly anchored in the bore. Clearly, the attainable shape of such an anchoring also depends, in particular, on the design of the dowel tip.

When connecting surfaces with the method according to the invention, it may be advantageous to equip the thermoplastic layer with energy directing elements as is, for example, known from ultrasonic welding methods for plastic parts. This is particularly advantageous in instances in which the surfaces to be welded together are very smooth. In the variation according to Figure 3 (welding of wood parts and thermoplastic parts), energy directing elements may be used for ensuring that the thermoplastic part is only heated and plasticized on its surface that needs to be connected to the wood part.

Energy directing elements essentially consist of points or lines that protrude from the /19

surfaces to be connected and represent the locations, at which the plasticizing begins first under the influence of ultrasonic waves.

Energy directing elements can be applied onto varnish layers by means of screen printing points or incorporated into film material (variation according to Figure 2) by structuring the film material accordingly. It was determined that specially applied energy directing elements are usually not required when connecting varnished wood parts because the structure of the varnish layer and the roughness of the varnished wood surface are sufficiently uneven for fulfilling the function of the energy directing elements.

Figure 12 schematically shows (in the form of a section through parts 10 and 11 before and after they are connected to one another) the attachment of an end strip 10 that consists of a thermoplastic material onto the end face of a particle board 11. In this case, the surface of the end strip which needs to be connected to the particle board contains energy directing elements in the form of longitudinally extending elevations.

<u>Claims</u> /20

1. Method for joining together parts that consist at least partly of wood or wood-like materials, characterized by the fact that at least one thermoplastic layer (L,5) is placed between the surfaces of two parts (A/B,C/D,E/F) which need to be joined together, by the fact that the parts and the least one thermoplastic layer are held such that the surfaces to be connected contact one another, and by the fact that at least one of the two parts is then mechanically excited such that a welding connection is produced by means of the at least one thermoplastic layer.

2. Method according to Claim 1, characterized by the fact that the mechanical excitation is realized with ultrasonic waves.

3. Method according to Claim 1 or 2, characterized by the fact that the surfaces of the parts to be joined together are pressed against one another during the mechanical excitation.

4. Method according to Claim 3, characterized by the fact that the parts are additionally pressed together for the duration of a holding time after the mechanical excitation ceases.

5. Method according to one of Claims 1-4, characterized by the fact that the at least one thermoplastic layer (L) consists of a layer of a protective and/or colored varnish that is applied /21
onto wood or a wood-like material, wherein said varnish contains at least one thermoplastic component.

6. Method according to Claim 5, characterized by the fact that the varnish consists of an acrylic varnish.

7. Method according to one of Claims 1-4, characterized by the fact that the at least one thermoplastic layer (5) consists of a thermoplastic film or powder layer or of a material with at least one thermoplastic component which is arranged between the parts to be joined together.

8. Method according to Claim 7, characterized by the fact that the film or the powder layer consists of a copolymer of polyamide or polymethylene methacrylate (PMMA).

9. Method according to one of Claims 1-4, characterized by the fact that the at least one thermoplastic layer consists of a surface layer on one of the parts (F) to be joined together, wherein said surface layer consists of a thermoplastic material or of a material with at least one thermoplastic component.

10. Method according to Claim 9, characterized by the fact that the thermoplastic material consists of polymethylene methacrylate (PMMA), acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), polyethylene (PE) or styrene-acrylonitrile (SAN).

11. Method according to Claim 9 or 10, characterized by the fact that one of the parts to be /22
joined together which consists of a thermoplastic material or of a material with at least one thermoplastic component is a dowel (8), and by the fact that the other part to be joined together consists of a wood part with a bore (7) that essentially corresponds to the dowel (8).

12. Method according to Claim 11, characterized by the fact that the dowel (8.1,8.2) contains steps, at which the cross section of the dowel is tapered, by the fact that the bore (7.1,7.2) also contains steps or is continuously tapered toward the inside, and by the fact that the smallest bore cross section is smaller than the smallest dowel cross section.

13. Method according to one of Claims 2-12, characterized by the fact that the parts to be connected are clamped between an essentially plane sonotrode working surface (1) and an anvil surface (2), by the fact that the surfaces to be joined together are arranged parallel and/or obliquely referred to the sonotrode working surface (1), and by the fact that the size of the sonotrode working surface essentially is chosen identical to the projection of the surfaces to be joined together.

14. Method according to one of Claims 2-12, characterized by the fact that the parts to be connected are clamped between an essentially plane sonotrode working surface (1) and an anvil surface (2), by the fact that the surfaces to be joined together are arranged perpendicular to the sonotrode working surface, and by the fact that the sonotrode working surface is arranged on one (A) of the parts (A, B) to be connected directly adjacent to the connection to be produced.

15. Method according to one of Claims 2-14, characterized by the fact that the excitation is /23
carried out with ultrasonic waves with a frequency between 20 and 40 kHz.

16. Method according to Claim 1, characterized by the fact that the mechanical excitation is realized in the form of friction between the surfaces to be connected.

17. Method according to one of Claims 1-16, characterized by the fact that the at least one thermoplastic layer contains energy directing elements on at least one of its surfaces.

18. Utilization of the method according to one of Claims 1-17 for manufacturing frames of various varnished or unvarnished wood parts.

19. Utilization of the method according to one of Claims 1-17 for attaching end strips of wood, of a thermoplastic material or of a thermosetting material onto the end faces of particle boards.

20. Utilization of the method according to Claim 11 or 12 for attaching fittings of plastic or of materials coated with a plastic onto wood parts.

21. Utilization according to Claim 20, characterized by the fact that the dowels are /24
integrally formed onto the fittings.

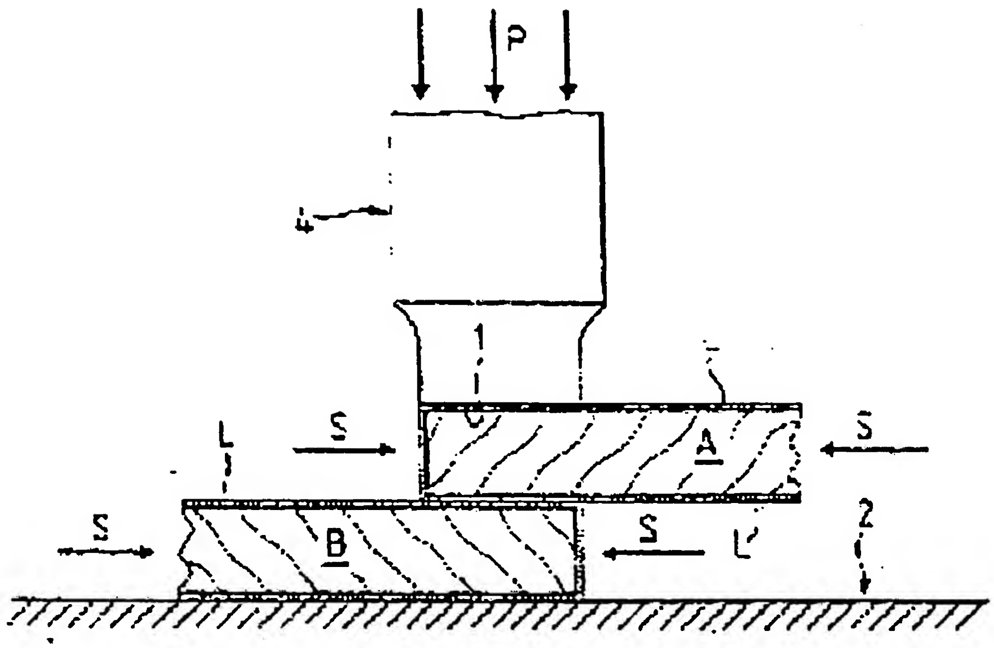

FIG. 1

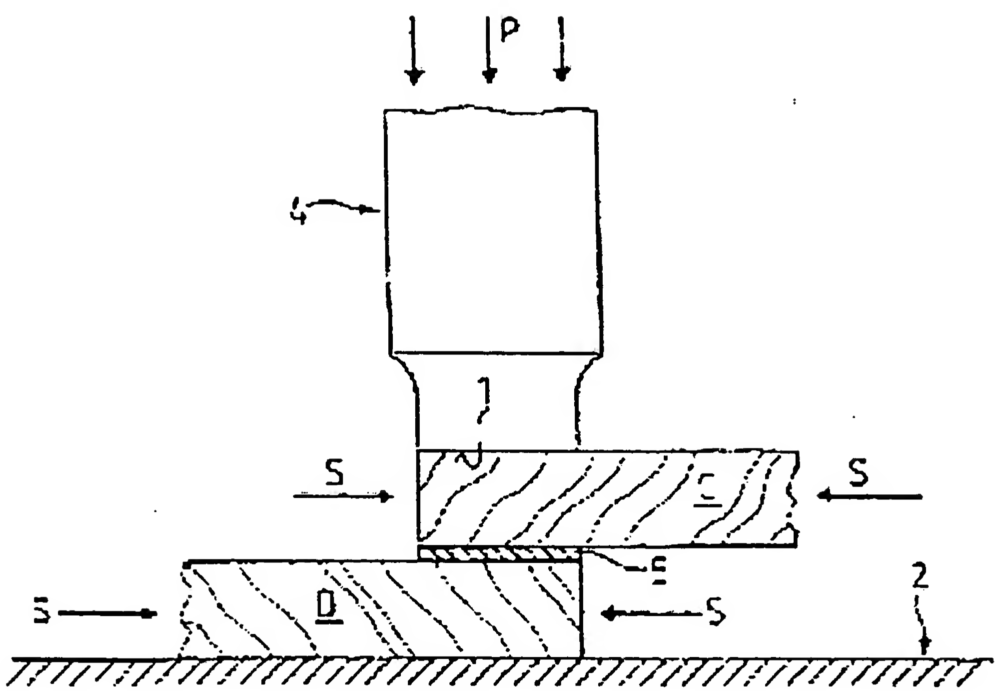

FIG. 2

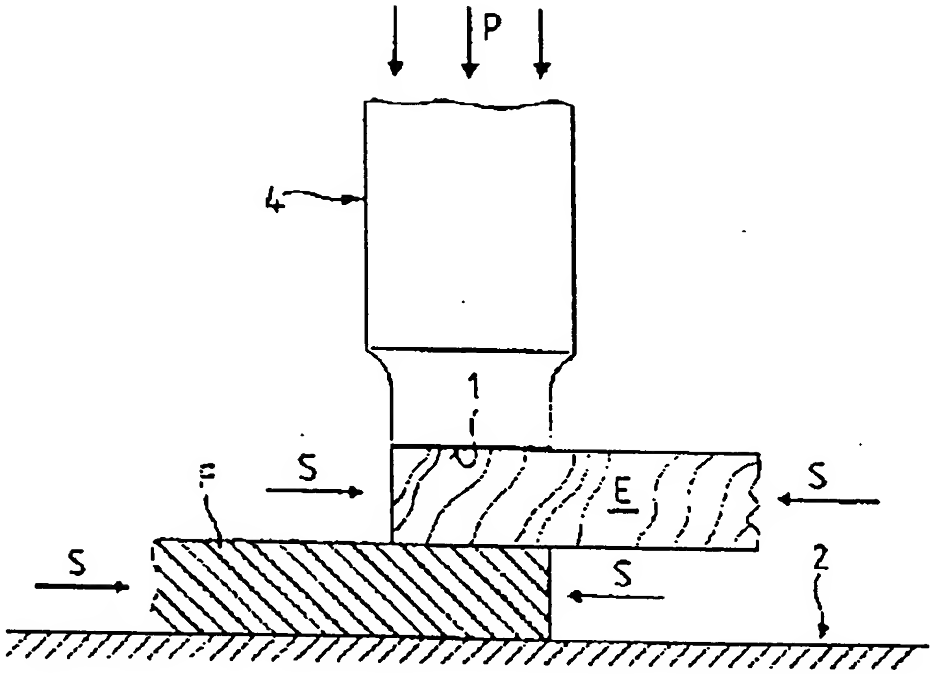

FIG. 3

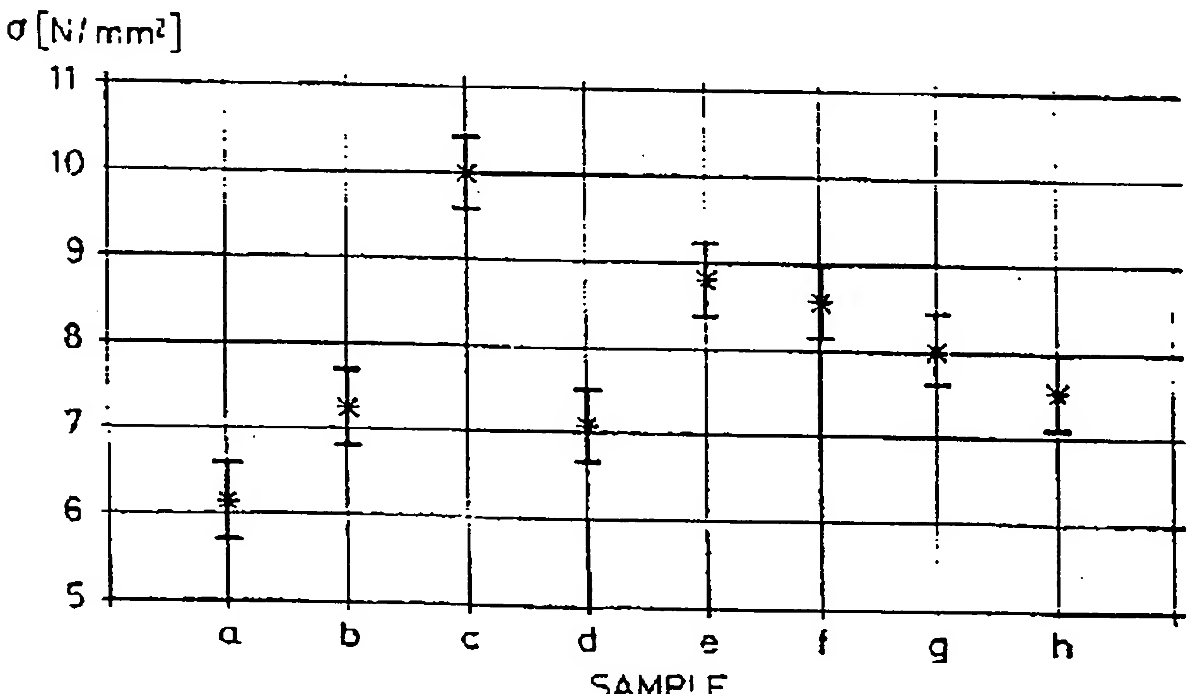

FIG. 4

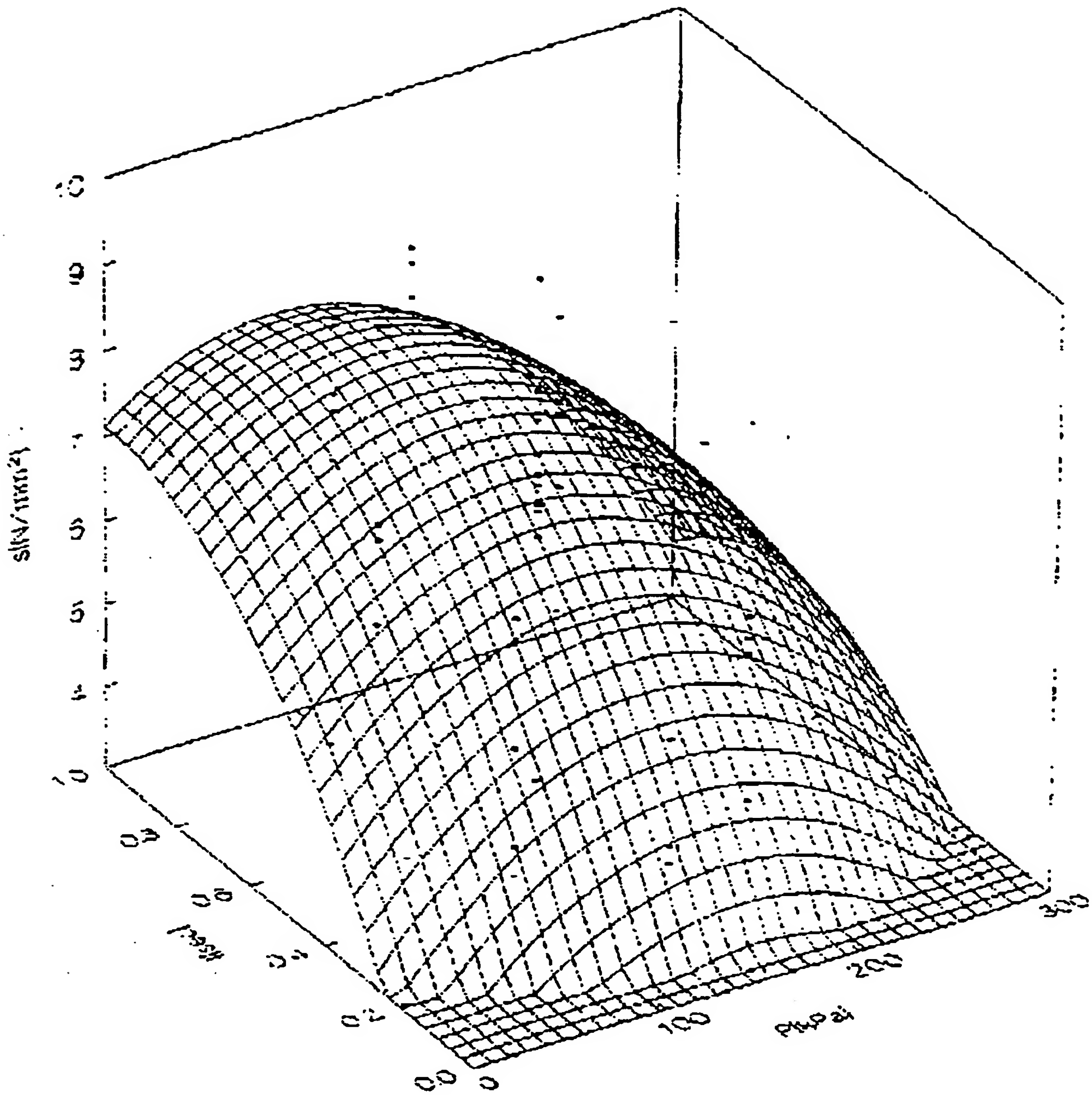

FIG. 5

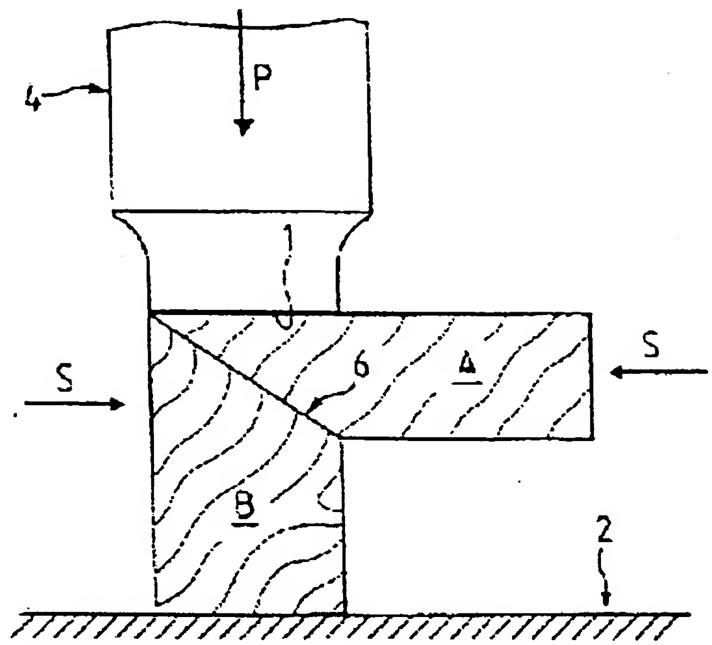

FIG. 6

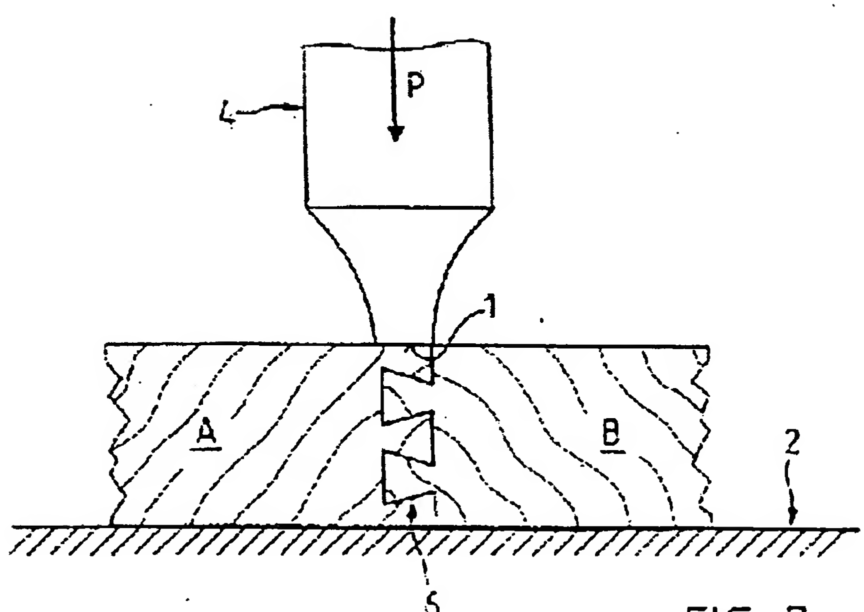

FIG. 7

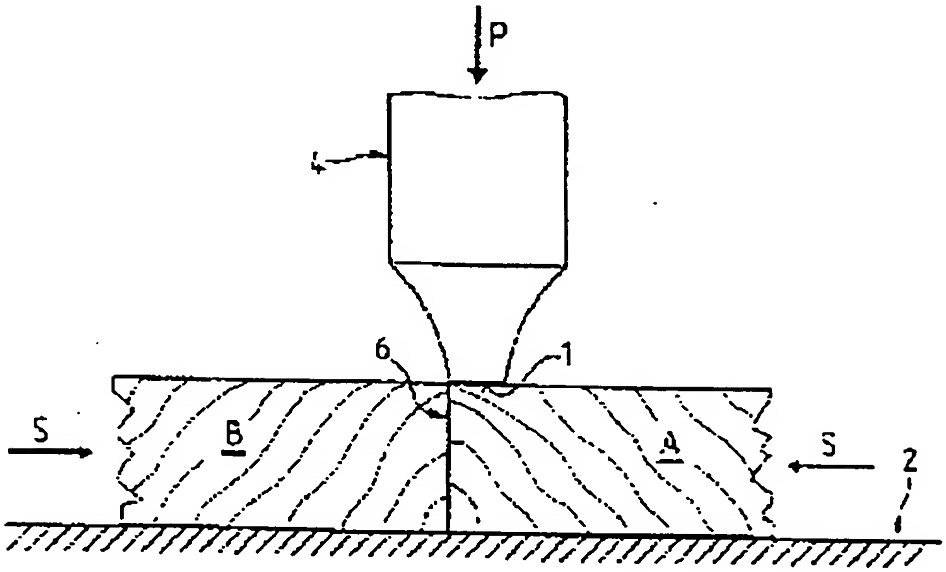

FIG. 8

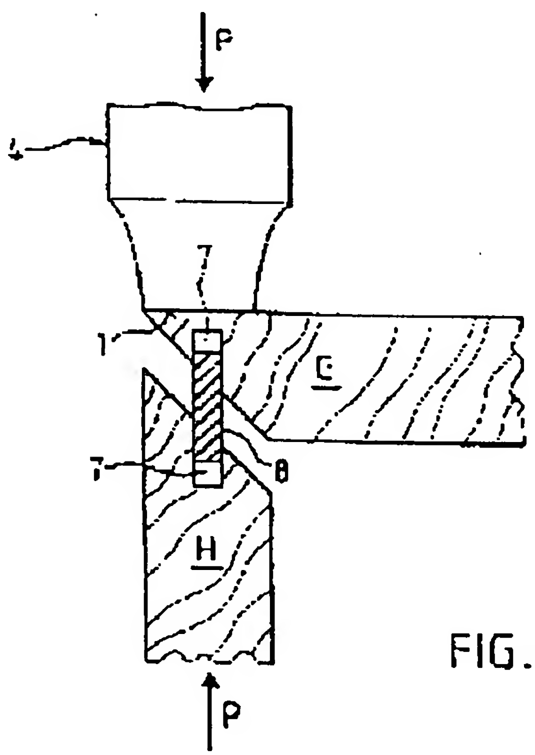

FIG. 9

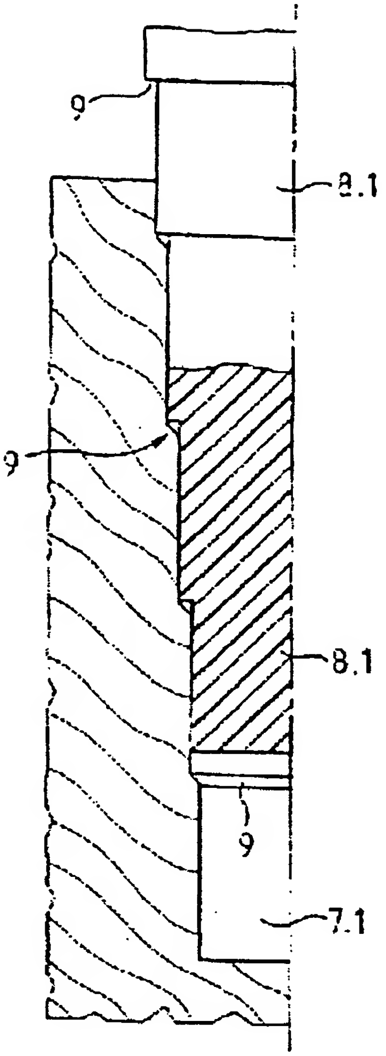

FIG. 10

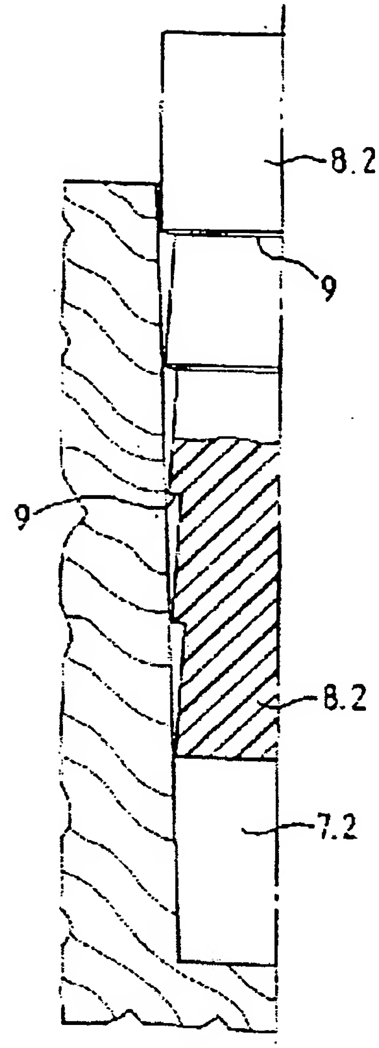

FIG. 11

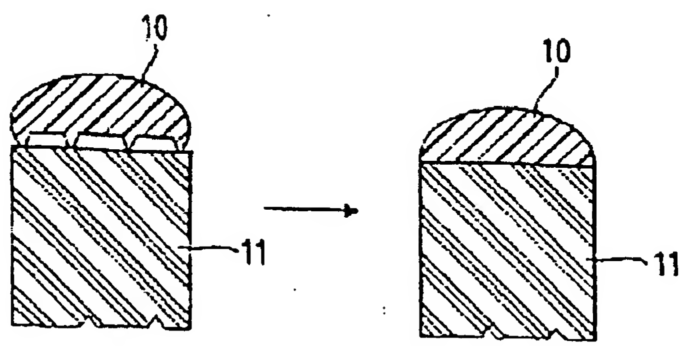

FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 95/02527

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16B11/00 B29C65/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,2 455 502 (MECASONIC SA) 28 November 1980	1-4,9, 10,13, 16,18,19
Y	see page 1, line 32 - page 2, line 18; claim 1; figures 1,2	11,12, 14,17, 20,21
Y	DE,A,24 18 198 (REICH MASCHF GMBH KARL) 16 October 1975 see page 3, line 15 - line 23; claim 1	11,12, 20,21
Y	FR,A,2 205 402 (WAVIN BV) 31 May 1974 see page 5, line 25 - line 31; figure 2A	14
Y	US,A,4 169 751 (YEN EDWARD C) 2 October 1979 see abstract	17

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search
5 October 1995

Date of mailing of the international search report
10.10.95

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 95/02527

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	DE,A,38 28 340 (DAIMLER-BENZ AG) 13 July 1989 see claims 1,3; figure 1 ---	1-4, 7-10,13, 16,18,19
X	EP,A,0 269 476 (ICC SA) 1 June 1988 see claims 1-3,5; figure 1 ---	1-4,9, 10,13, 16,18,19
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A	FR,A,2 615 786 (MONOPLAST SA) 2 December 1988 see claims 1,2; figure 3 ---	1,13
A	FR,A,1 407 582 (CHEMISCHE FABRIK STOCKHAUSEN & CO) 26 November 1965 see abstract ---	1,7,8
A	FR,A,1 560 179 (FIRMA A. HELD) 14 March 1969 see abstract; figures 1-13 ----	1,11,12

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International Application No
PCT/EP 95/02527

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Information on patent family members

International Application No
PCT/EP 95/02527

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